Anatomy. — *The fissures on the frontal lobes of Pithecanthropus erectus Dubois compared with those of Neanderthal men, Homo recens and Chimpanzee.* By C. U. ARIËNS KAPPERS.

(Communicated at the meeting of December 22, 1928).

Brief descriptions of the frontal fissures on the endocranial cast of Pithecanthropus erectus are given by DUBOIS himself [1]) and by KEITH [2]), along with some remarks in TILNEY's and RILEY's book [3]).

Of the illustrations hitherto given those of KEITH are the most instructive but also his description is not complete. Also the lunate sulcus may be observed, especially on the right occipital lobe, where the ram. posterior calcarinae seems to be indicated, together with a slight impression behind it, caused perhaps by the posterior limb of ELLIOT SMITH's superior occipital furrow (Ypsiliformis mihi, triradiatus LANDAU). On the left hemisphere the sulc. lunatus cannot be recognized with equal probability.

As far as concerns the central sulcus I can only give a supposition regarding its ventral ending (see below).

The frontal fissures, however, throw a very interesting light on this object.

Starting with the *right frontal lobe* I shall indicate its fissures by figures in order to avoid the precocious homologies, necessarily included in names.

I first call attention to the incision of the orbital margin of the frontal lobe (1, fig. 1). This indentation continues backwards underneath the orbital operculum and forms its ventral border. The upper limit of this operculum is indicated by fissure 2. On the operculum orbitale itself an axial groove 3 appears. This has only a short frontal course connecting in the middle with the curved fissure 4, that encircles fissure 2 and then, — after giving off a small caudo-ventral branch 4^1 continues with a new curve in the slightly oblique X shaped fissure 5. Where the latter furrow ends with a caudo-dorsal branch 5*a*, a strong frontal fissure 6 proceeds from it in the direction of fissure 7. This fissure 7 has a strong caudal

1) DUBOIS. Remarks upon the braincast of Pithecanthropus erectus: Proc. of the 4th internat. Congress of Zoology Cambridge, 1898. DUBOIS. On the principal characters of the cranium and the brain etc. of Pithecanthropus erectus. Proceed. of the Kon. Akad. van Wetenschappen, Amsterdam, Vol. 27, 1924, N⁰. 3 and 4; for figures see ibidem N⁰. 5 and 6.

2) Report on the Galilee skull. Publ. of the Brit. school of Archeology in Jerusalem, London, 1927.

3) TILNEY and RILEY. The brain from Ape to Man. HOEBER, New-York, 1928.

branch *7a* [1]) issuing from it where it is connected with 6. Frontally, fissure 7 has two medio-dorsal branches *7b* and *7e*. The branch *7b* shows a bifurcation, the frontal limb of which establishes a connection with 11*c*, while its caudal limb proceeds in the direction of 11*b* without, however, reaching this branch.

At the frontal end of 7 two ventral branches occur, *7c* and *7d*. The connection of *7d* with 7 is only a superficial one, but is nevertheless clearly expressed. At its ventral end *7d* is very deep.

Between 7, 4 and 5 an *intermediate fosset* 8 occurs. On the right hemisphere this fosset is entirely independent, having no connection whatever with any of the surrounding fissures.

Frontally and ventrally of 7 lies fissure 9 that disappears under the fronto-orbital margin (the cast ends at the dotted line).

Finally, in front of 9 a shallow dimple, 10, occurs, apparently related to the border of the orbital rostrum.

On top of this whole system groove 11 appears, beginning caudally as a vague impression, the caudo-dorsal surface of the lobe being nearly flat. At 11*a* it has a small ventral offshoot, then another one, 11*b*, running in the direction of the posterior bifurcation of *7b* without reaching it, while 11*c* is distinctly connected with *7b*. Opposite 11*c* a dorso-medial offshoot

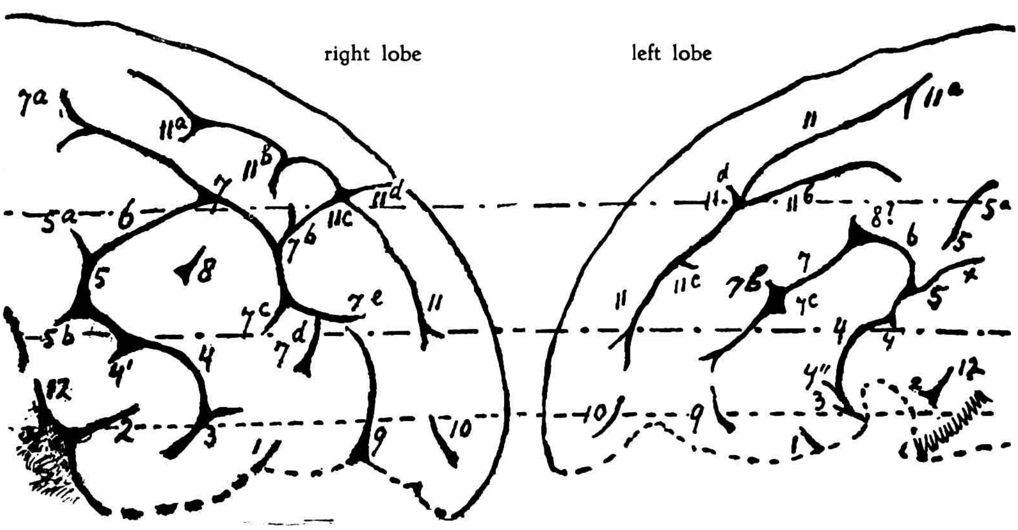

Fig. 1. The fissures on the frontal lobes of Pithecanthropus erectus Dubois.

11*d* reaches the medial hemispherial wall. Frontally, fissure 11 ends in a small bifurcation.

This is the structure of the right frontal lobe, to which I have only to add that at the posterior border of the lobe a fissure 12 occurs proceeding in the direction of the fossa Sylvii in which also 2 disappears. On top of 12,

[1]) The caudal bifurcation of this posterior branch *7a* is perhaps the beginning of a superior precental sulcus (see below p. 190 and fig. 4).

slightly behind it, a shallow deepening occurs (see fig. 1 behind *5b*), not numbered in my figure, representing perhaps the ventral end of the centralis.

The fissuration on the *left frontal lobe* is equally as simple, as on the right. It is even slightly simpler in so far as the curve of 4 is somewhat steeper. For the rest its fissuration much resembles the one on the right lobe. As only a small part of the orbital operculum is left on this side, groove 1 is hardly expressed, and its caudal continuation under the operculum is missing.

Fissure 2 is perhaps indicated by a small frontal offshoot of a dimple, the larger part of which (12) runs dorsally. The axial groove of the orbital operculum 3 is indicated and connects here also with 4, the curve of which runs slightly steeper than on the right. Somewhat more dorsally from this curve a small offshoot proceeds frontally, 4″, which is missing on the right lobe. Dorsocaudally fissure 4, after making a new curve, connects directly with the lower end of fissure 6, fissure 5 being only indicated by a dorso-caudal groove *5a*, which proceeds a little further in a dorso-caudal direction than indicated in my textfigure (cf. the plate). In the transverse fissure 5* a part of 5 is also included. The curved fissure 6 runs less dorsally on the left lobe than on the right one and an independent *intermediate fosset* 8 is failing on the left lobe.

In his interesting researches on the frontal lobe S. SERGI [1]) has frequently pointed out the various ways in which interfissural fossets behave, being sometimes taken up in adjacent grooves. As groove 7 on the left hemisphere runs more ventrally than on the right it is not impossible that this fosset 8 is assimilated here with 7 (8? fig. 1).

Fissure 7 has only a slight indication of one ventral offshoot, which might correspond with *7c* on the other side. Frontally, 7 ends in a bifurcation.

The sulcus 11 lying on top of this system differs somewhat from 11 of the other side in giving off a large caudoventral branch *11b*. This may be explained by the more ventral course of 6 and 7 (see above). Opposite to *11b* a small offshoot runs medially (*11d*), but does not reach the mesial margin of the hemisphere.

At the ventral margin of the left frontal lobe again the sulci 9 and 10 are indicated. Of these fissures 9 proceeds in the direction of 7.

Finally, this lobe also shows a shallow dimple behind 5* (not indicated in my figure), located, as its right homologue, immediately in front of the anterior branch of the arteria meningea media (see VLASSOPOULOS' drawings).

If I now compare these grooves with those that may be made visible by projection shadow and controlled by touch on the endo-cranial casts of Neanderthal men [2]) (fig. 2 and 3) it appears that their fissuration, though

[1]) S. SERGI. Sulle variazioni dei solchi del lobo frontale negli Hominidae. Rivista d'Anthropologia, Vol. 18, 1913.

[2]) For this purpose I used the endocranial casts of the Düsseldorf, La Chapelle, La Quina and Rhodesia man. The fissures on my endocranial cast of the Gibraltar woman are not distinct enough for this purpose. For these I refer to Sir ARTHUR KEITH's Antiquity

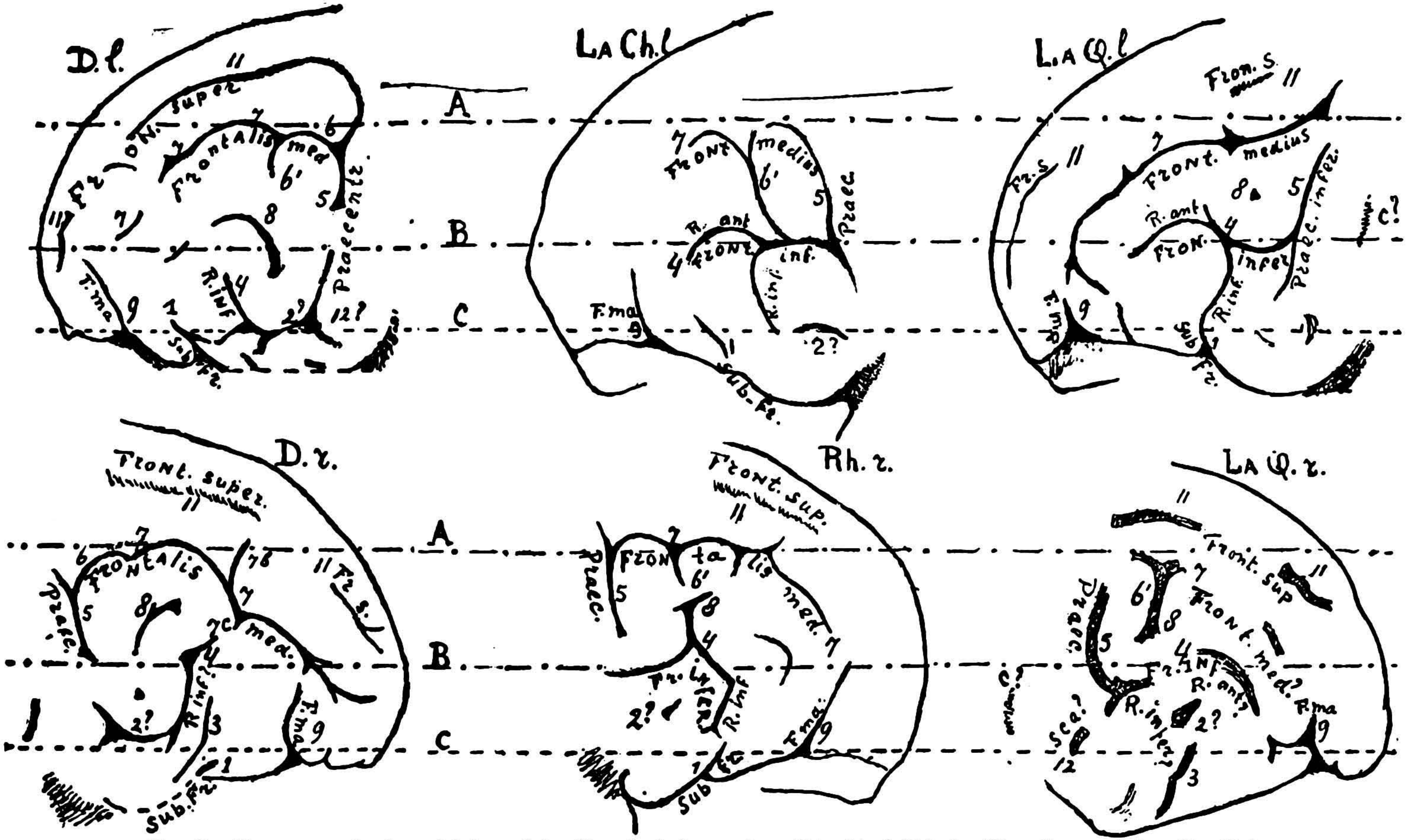

Fig. 2. Fissures on the frontal lobes of the Neanderthal man from Düsseldorf (D.), La Chapelle aux Saints (La Ch.), La Quina (La Q.) and Rhodesia (Rh.); *l* = left hemisphere, *r* = right hemisphere.

less distinct than in the ape-man of Trinil, reminds us in several respects of the latter.

This is particularly evident in the fissures 5, 6 and 7 of the right lobe of Pithecanthropus and the Düsseldorf Neanderthal men. On the left lobe of the Düsseldorf and La Chapelle cast an additional offshoot 6′ is indicated. This also occurs on the right side of the Rhodesian cast, a relation reminding us of that found in recent men (fig. 4 A and B). Also the relations at the ventral margin of the lobes — clearly indicated in some Neanderthal men — show a great resemblance with Pithecanthropus, specially as far as regards fissure 1 and 9. Fig. 3 shows the basal course of fissure 1, which I called *S. subfrontalis* [1]). The system of fissures numbered 4, however, varies a good deal in Neanderthal men, and differs from the course of this system in Pithecanthropus. On the left lobe of the La Chapelle and La Quina man it especially shows a larger and frontally higher curve than on the Trinil cast by the nearly horizontal course of its ramus anterior (R. ant. fig. 2).

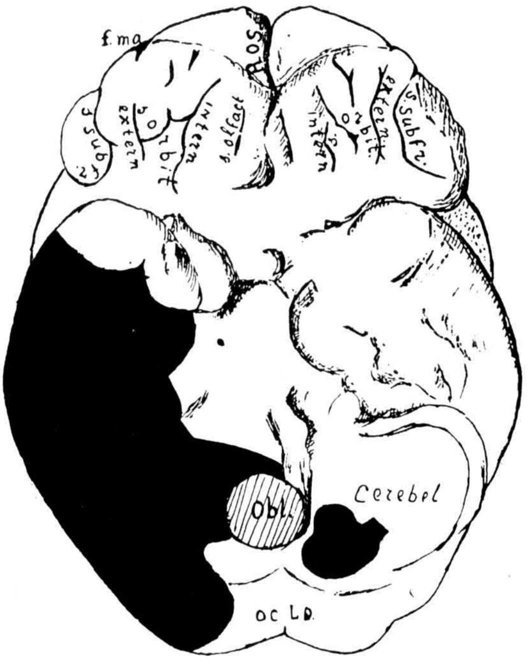

Fig. 3. Basal aspect of the endocranial cast of the skull of Rhodesia.

I consider the enlargement of the curve of the *S. frontalis inferior* (for this is 4) as an indication of a further development of BRODMANN's subregio

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of man, 7th Ed., Vol. II (p. 618 fig. 223), where also a profile drawing of the original Piltdown cast is given (p. 616, fig. 221), together with a very instructive picture of the endocranial cast of an Australian aboriginal (fig. 222).

[1]) Not to be confused with EBERSTALLER's s. subfrontalis (= calloso-marginalis Autorum).

frontalis inferior, the region that lies underneath the inferior frontal sulcus and that caudally includes BROCA's speech centre (on the left side).

Although it is remarkable that in the Neanderthal casts [1]) only faint impressions of rami anteriores fossae Sylvii are found (fig. 2 : 2 ?) we must remember that SYMINGTON [2]) never found impressions of these branches in his endocranial casts of recent men.

For comparison with Homo recens I use MAZZOTTI's cast which is, just as the other casts, available to everybody, so that everyone may verify my interpretation. *In doing so one has to remember that this cast of Homo recens has been made from the brain itself, while the others are endocranial casts. This means that many more fissures are visible in the former.*

Also in this model we find that groove 1, which, as comparisons with many recent brains show, may be either an independent groove, which may also here be called *s. subfrontalis* [3]), or a branch of the orbitalis externa (the lateral limb of BROCA's "scissure en H"), or it may even be entirely confluent with that limb. Also here, this groove runs backwards underneath the orbital operculum, and may appear again on the surface behind it. The orbital operculum is dorsally bordered by a fissure *2h*, that runs more horizontally than fissure 2 in Pithecanthropus, and, apparently, is the *ramus anterior horizontalis fossae Sylvii* separating the frontal from the orbital operculum.

Groove *2h* — together with the more caudal and perpendicular groove *2a* (*ram. anterior ascendens fossae Sylvii*) embraces the frontal operculum or cape of BROCA — well developed on both sides of this model.

The great development of the frontal operculum also appears from its axial fissure (*fiss. axialis operculi frontalis :* ax. o. fr., fig. 4) that enlarges its surface (not to be confused with the axial furrow of the orbital operculum). The axial furrow of the orbital operculum 3 is pushed somewhat downward by the development of the frontal operculum, and on the left hemisphere is elongated in a frontal direction correspondingly with the enlargment of the frontal curve of the *frontalis inferior* (4), with which it is connected on both sides as in Pithecanthropus.

On the right side the *inferior frontal fissure* (4), in addition to the fissura axialis operculi frontalis has still another caudo-ventral branch, below the former, that also enlarges the surface of the frontal operculum.

The frontal curve of 4 is very large, especially on the left hemisphere (fig. 4*B*). From its posterior curve a sulcus proceeds between the *ram.*

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[1]) In their studies on the casts of La Chapelle aux Saints and La Quina (l. c. infra) BOULE and ANTHONY, sometimes call my fissure 1 : s. p. a. (scissure présylvienne antérieure) or o. (orbitaire) or o. i. (orbitaire interne). They, however, also pointed out that its homology with an orbital sulcus is more probable than with a ramus anterior horizontalis fossae Sylvii.

[2]) SYMINGTON Sir John Struthers lecture. Edinburgh Medical Journ. Febr. 1915, p. 17. See, however, also BOULE and ANTHONY Neopallial morphololy based on endocranial casts. Journ. of Anat. and Phys. Vol. **51**, 1917.

[3]) Not to be confused with EBERSTALLER's subfrontalis (=calloso-marginalis of the author's).

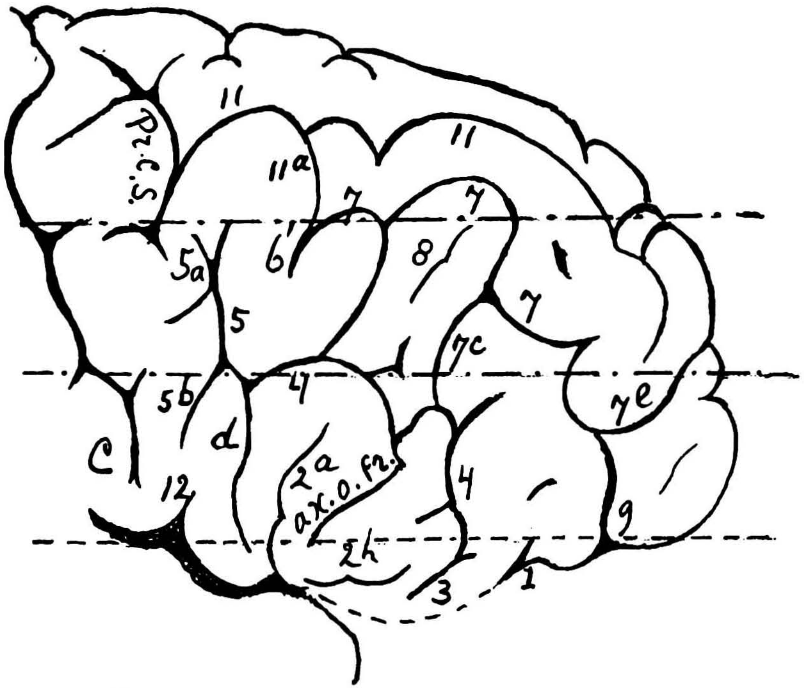

Fig. 4A. Fissures on the right frontal lobe of a recent man.

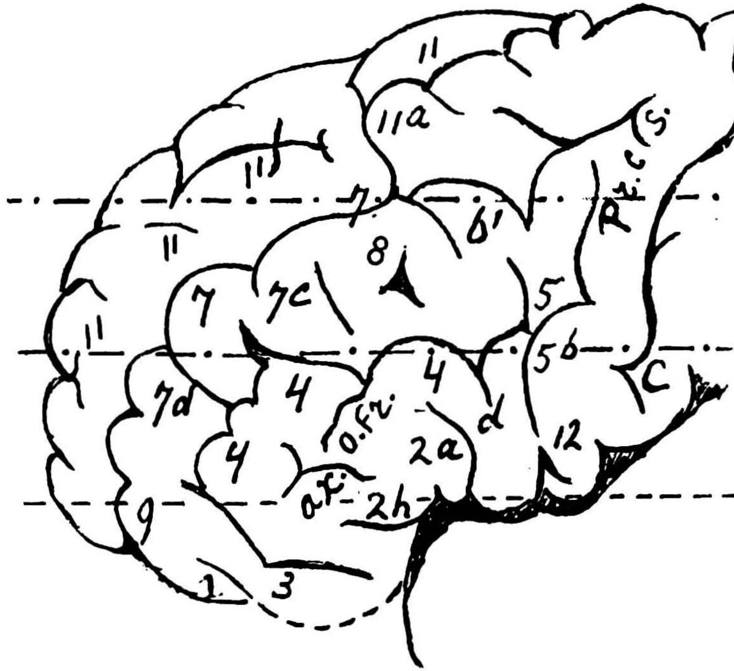

Fig. 4B. Fissures on the left frontal lobe of a recent man.

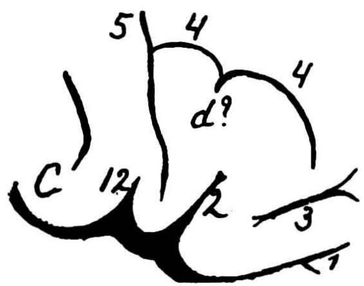

Fig. 4C. One of Retzius' men in whom only one ramus anterior fossae Sylvii (2) occurs (cf. the right lobe in fig. 1).

anterior ascendens fossae Sylvii and the *f. precentralis* (5) the *f. diagonalis* (*d*) of which no trace is visible in Neanderthal casts. This, however, does not prove that a diagonalis was missing in Neanderthal brains since SYMINGTON (l.c.) showed that this part of the pallium (in recent men at least) gives no or only very faint impressions on the skull.

Here the question of the homology of fissure 2 in Pithecanthropus must be discussed, and, with it, the question of the homology of fissure 12 in the ape-man of Java, and 12 ? in Neanderthal casts.

At first sight one might be inclined to homologize fissure 12 of the Trinil cast with 2*a* of recent man, and 2 of the Trinil cast with 2*h* of the latter. DUBOIS seems to have done this in his lecture at Cambridge (l.c. primo, p. 83) saying : "the two segments of this figure (he apparently refers to the curves of the frontalis inferior : 4) encircle the limbs of perfectly definite Y shaped anterior branches of the fissura Sylvii, the stem of which is about 1 cm long".

In his last description, however, (l.c. secundo, p. 273) he speaks only of "a strong front branch of the Sylvian fissure".

I am also inclined myself to accept the presence of only one single anterior branch of the Sylvian fossa in Pithecanthropus for the following reasons. The *ramus ascendens anterior f. S.* always lies in front of the *precentral fissure* (5) while in Pithecanthropus fissure 12 lies behind the ideal elongation of the precentral. So fissure 12 of Pithecanthropus can be only the *f. subcentralis anterior,* a fissure very constant also in anthropoids. Consequently fiss. 2 in the Trinil cast is a single ram. anterior f. S., as sometimes also occurs in anthropoids, where two separate rami anteriores f. S. never occur according to EBERSTALLER [1]), though according to my experience and that of others a *Y* shaped ramification is occasionally observed here (cf. fig. 5 left lobe). Even in man a single ramus anterior is no exception. EBERSTALLER found a single ram. anterior in 24 % of his German brains, CUNNINGHAM [2]) in 27 % of his Irish material, and QUANJER [3]) in 18 % of his Dutch material. It is remarkable that CUNNINGHAM as well as QUANJER found this condition three times oftener on the right than on the left hemisphere. So CUNNINGHAM saw a single ramus anterior f. S. in 41 % of his right hemispheres. Also RETZIUS [4]) found this condition quite frequently in Swedish brains. In fig. 4C I reproduce one of his cases (l.c. plate 67, fig. 1). The resemblance of this case with the relations in Pithecanthropus (fig. 1 right lobe) is striking and not only concerns fissure 2, but also the combination of 12 and 2 and

1) EBERSTALLER. Das Stirnhirn. Urban und Schwartzenberg, Leipzig und Wien, 1890.

2) CUNNINGHAM. Contribution to the surface anatomy of the cerebral hemispheres with a chapter on cranio-cerebral topography. Memoirs N⁰. 7 Roy. Irish Academy of Sciences 1892 and CUNNINGHAM. The insular district in the cerebrum of anthropoid apes. Journ. of Anat. and Phys., vol. **31**, 1897.

3) QUANJER. Zur Morphologie der Insula Reilii und ihre Beziehung zu den Opercula. Petrus Camper, Deel 2. 1902.

4) RETZIUS, Das Menschenhirn, Stockholm, 1896.

the surrounding *f. frontalis inferior* (4) and its ventral offshoot 4′ (= *d*?, a rudimentary diagonalis?). Similar relations may be found in human fetuses.

Considering the fact that on both hemispheres of the Pithecanthropus only a single anterior branch of the f. Sylvii is indicated and that on the left hemisphere the inferior frontal convolution is still smaller than on the right, we have no morphological reasons to assume that this creature possessed the ability of speech although neither can it be proved that it could not speak [1]). In recent men the inferior frontal sulcus very often has dorsal branches, also indicated in the Neanderthal (see fig. 2 La Chapelle and La Quina l.; Düsseldorf and Rhodesia r.) but not in the Trinil cast.

The *intermediate fosset* 8, occurring in the ape-man and Rhodesian man on the right, in the Düsseldorf on both and in the La Quina man on the left hemisphere, is also observed in recent men in the form of a large triradiate star situated somewhat more frontally (see specially the left side of the model; on the right lobe this fosset seems to be grown out in the form of a transvere fissuret 8.

The *inferior precentral fissure* (5) in recent man frequently has also a ventro-caudal branch *5b*, which, however generally extends far downward as does the diagonalis. This ventral extension is absent in the Trinil cast and probably did not occur on the Pithecanthropus brain, as (at least on the right) the adjacent fiss. 2 is so well expressed.

In my Neanderthal casts a ventral extension of the inferior precentral is oftener indicated on the left hemispheres than on the right which does not however, prove that it did not exist on the right lobes, since SYMINGTON has observed that this region is not very apt to make impressions (see above).

The downward curve 6′ of the midfrontal sulcus (7) present in figs *4A* and *4B* is also indicated in several Neanderthal men. The midfrontal sulcus (7) itself in fig. 4 continues in the superior precentral, which in the Neanderthal casts it only does in the La Quina man [2]). In all others it continues in the inferior precentral.

Frontally, where the midfrontal fissure curves down, it either shows a tendency to connect or a real connection with the *fronto-marginal* (9) in recent men, as is also indicated in Neanderthalmen and Pithecanthropus.

Dorsally another branch (7e), also indicated in the Trinil and Düsseldorf casts, runs to the medial margin of the brain in fig. 4A.

Of the *superior frontal sulcus* the caudal part was absent in the Neanderthal and Trinil casts, but it has certainly been present seeing that it constantly occurs in anthropoids. The frontal end of 11 in fig. 4B reminds us strongly of the relations in the Neanderthal casts (fig. 2 D.r.) by its discontinuity.

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[1]) According to many linguists human speech originates in uttering emotional and imitative sounds. As these faculties also occur in several animals, it seems very difficult to say where „speech" begins.

[2]) And perhaps in the Gibraltar cast (see KEITH, Vol. II, fig. 223).

We thus find a transition between the Pithecanthropus, Neanderthal and recent men, but also marked differences, e.g. in the development of the frontal operculum, not delimited in the Trinil cast and not clearly delimited in Neanderthal casts while in Homo recens in 86 % of the left and in 59 % of the right hemispheres it is well limited by two anterior branches of the fossa Sylvii. Furthermore, the curve of the inferior frontal sulcus is considerably enlarged in recent men (especially on the left lobe) a process already indicated in Neanderthal casts. There also is a marked increase of the area below the mid frontal sulcus, which area in Neanderthal but specially in recent men is larger than on the Trinil cast. In recent men a special enlargement may be observed in the region between the fosset 8 and the precentral sulcus (the so called foot of the midfrontal convolution).

As far as concerns the increase of the frontal operculum we know that this operculum, and the area immediately in front of it, corresponds to BRODMANN's subregio frontalis inferior that acts a large part in speech (on the left in right handed people). The functions of the cortex between 8 and 5 are less known. This area belongs to the regio frontalis granularis of BRODMANN [1]) of which this author also showed the progressive development in primates and in men. According to SAHLI's [2]) researches the foot of the midfrontal convolution contains *Prévost's* centre for the conjugated deviation of head and eyes. Although this frontal center already occurs in carnivora, monkeys and apes (FERRIER) [3]), it may be that its surrounding is specially concerned in the enlargement of the foot of the mid frontal convolution in recent men. This would not be so strange since the conjugated deviation of the eyes and head is an important function in circum-spection, enabling men (and animals) to fix lateral objects, for which reason it has been also called "spy centre".

Before ending I shall compare the frontal lobes of the Trinil cast with those of a Chimpanzee, the fissures of which show a great resemblance with those of the former. It is interesting that also SCHWALBE [4]) and WEINERT [5]) considered the Chimpanzee as the anthropoid whose skull structure comes nearest to that of the Trinil man, while MINGAZZINI [6]) found the Chimpanzee's fissuration coming nearer that of men than the Orang's fissuration does. Similarly KEITH and MOLLISON believe the

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[1]) BRODMANN. Vergleichende Lokalisationslehre der Groszhirnrinde in ihren Prinzipien dargestellt auf Grund des Zellenbaues. Joh. Ambr. Barth, Leipzig 1909.

[2]) SAHLI. Beitrag zur corticalen Lokalisationslehre des Centrums für die conjugierte Seitwartsbewegung etc. Deutsches Archiv für Klin. Medizin, Bnd. **86**.

[3]) FERRIER, Vorlesungen über Hirnlokalisation, p. 32, Deuticke, Leipzig u. Wien, 1892.

[4]) SCHWALBE. Studien über Pithecanthropus erectus DUBOIS. Zeitschr. f. Morphologie und Anthropologie, Bnd. **1**, 1899.

[5]) WEINERT. Pithecanthropus erectus. Zeitschr. f. Anatomie und Entwicklungsgesch., Bnd. **87**, Heft 3 und 4, 1928.

[6]) MINGAZZINI. Beiträge zur Morphologie der äuszeren Groshirnhemisphärenoberfläche bei den Anthropoïden (Schimpanse und Orang). Arch. f. Psychiatrie, Bnd, **85**, 1928 (p. 212).

Chimpanzee to be nearer related to man than the Orang and even the Gorilla.

If in fig. 5 one eliminates the rostrum orbitale, which is largely missing in the Pithecanthropus cast, its resemblance to that of the Trinil man becomes still greater. But even then the more compressed shape of the Chimpanzee 's brain is striking, the shortness of the frontal lobes as compared with their height.

The antero-posterior shortening of the lobes, already expressed in the brachencephaly of this animal (index 84.5), is equally revealed in the course of their sulci which appear to be more pushed backward than in the Trinil man.

This is already seen from the course of the *S. fronto-orbitalis* [1] (1), which fissure is homologous to the *f. subfrontalis* mihi in Pithecanthropus, Neanderthal and recent men, but the dorsal part of which runs much steeper in the Chimpanzee and even shows a backward inclination on the right hemisphere of the latter [2]).

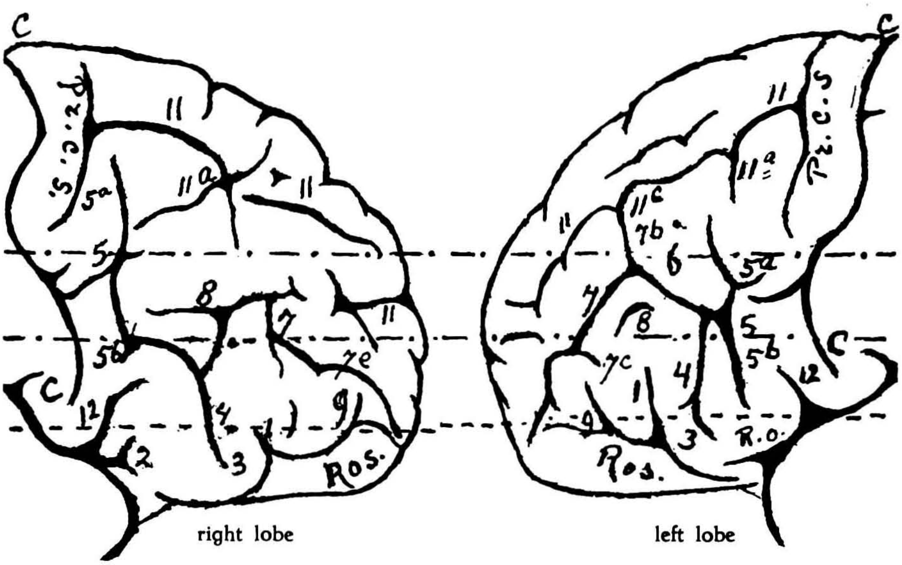

Fig. 5. Fissures on the frontal lobes of Troglodytes niger.

[1]) For other human homologies of the fronto-orbital sulcus mentioned by former authors I refer to my "Vergleichende Anatomie des Zentralnervensystems der Wirbeltiere und des Menschen", Vol **11**, p. 1147. I want to emphasize only that ELL. SMITH was right when he supposed that the larger part of the dorsal section of this sulcus disappears from the convexity in men. This process already begins in the Chimpanzee (c.f. the right and left lobe in fig. 5) in comparison with the Orang-Outan. Concerning the ventral (orbital) part of this fissure I can no more share the opinion of those authors who supposed that this part is represented by a the S. limitans anterior insulae in men. This part returns as s. subfrontalis, that may be very small in recent men or be connected with the fiss. orbitalis externa. After writing this I found that also KEITH has established the same homology of the fronto-orbital in his report on the Galilee skull (l.c. supra).

[2]) The steeper course of the dorsal part of the fronto-orbitalis is still more striking in the Orang-Outan whose brachencephaly is also greater (87.7).

With the *inferior frontal sulcus* (4) the more caudal position is equally evident, its curve in the Chimpanzee being much steeper, specially on the left hemisphere than in Pithecanthropus. The *midfrontal sulcus* (7) of the left lobe (fig. 5) resembles very much the course of the same sulcus on the right lobe of the Trinil cast, although its curve again is slightly more compressed.

In both a connection with the superior frontal sulcus occurs by means of *7b* and *11c*. On the right hemisphere the midfrontal sulcus is hardly recognized and apparently connected with the intermediate fosset 8, very large in fig. 5 and connected with the inferior frontal fissure (cf. the Rhodesia Neanderthalmen), as well as with the mid frontal sulcus (cf. the the right lobe of La Quina cast).

A point of resemblance between the right hemisphere of the Chimpanzee with the same in Pithecanthropus is the presence of a single ram. anterior f. Sylvii (2), which, however, in the Chimpanzee shows a bifurcation (thus establishing the well known *Y* form of this sulcus, which may also occur in men). This fissure (2) ends caudally in the fossa Sylvii in which also the subcentralis anterior (12) disappears.

It is evident that the area situated underneath the inferior frontal sulcus in the Chimpanzee is still smaller than in the Trinil cast, which not only appears from the steeper curve of 4, but also from the distance between 1 and 12 being smaller in the latter. Although this difference partly results from the smaller size of the orbital operculum it is largely due to the small development of the area situated behind and on top of it, the operculum frontale, which in man acts such a large part in speech.

In general lines, however, the resemblance between the Chimpanzee and Pithecanthropus is very great and the fissural pattern of the latter apparently forms an intermediate condition between that of the Chimpanzee and of Neanderthal men.

In its general shape the Trinil cast, however, comes nearer that of the brain of Hylobates syndactylus (encephalic index 80), especially as far as concerns the sagittal height indices of the calotte part. It also struck DUBOIS that the norma lateralis of his cast resembles in many respects that of Hylobates syndactylus. Nevertheless by its extremely simple fissuration, Hylobates is further removed from Pithecanthropus than any other anthropoid is.

Considering also its large skull capacity and cephalization coefficient [1]) it does not seem impossible that Pithecanthropus was a Hominide.

Its brainweight is generally compared with that of the average European (1300 gr. of men and women). If, however, we compare it with the lower living representatives of mankind, it approaches human conditions still more. So the brain weight in Australian aboriginals, according to DAVIS [2]),

[1]) DUBOIS calculated the cephalization coefficient of Pithecanthropus to be about twice as large as that of anthropoid apes, taking the femur as an indicator for body size and weight.

[2]) DAVIS. Contributions towards determining the weight of the brain in different races of men. Phil. Transact. of the Royal Soc. London. Vol. 158, 1869.

whose capacity estimations well accord with those found by TURNER (1230 cc) [1]) and DUCKWORTH [2]) (1246.5 cc), is no more than 1173 gr. (average for 17 men and 7 women).

DUBOIS' first estimation of the capacity of the Trinil skull was 855, which he later raised to 900 cc.

MC. GREGOR [3]) calculated the endocranial capacity to be about 940 ccm. WEINERT (l.c.) who took the average of four different methods of calculation found a still higher capacity, viz. 1000 ccm. Considering the fact that dried skulls always have a smaller capacity than fresh ones and adding 30 cc for this (50 cc in man) the original capacity might have been as much as 1030 ccm. Accepting as brain volume 91 % of this capacity we get 937 ccm brain, which, with an average specific weight (for white and grey matter) of 1.037 would give a brainweight of 972 grams, whereas the heaviest anthropoid brain hitherto weighed did not exceed 440 grams [4]).

So the brain of the ape man of Java weighed only 200 grams less than of Australians. Similar comparisons are made by DUBOIS with Andamanese and Weddahs (l.c. primo p. 85).

In connection with the intermediate character of Pithecanthropus I also may mention ELL. SMITH's *lunate sulcus* the position of which on the right corresponds with the top of the lambda suture, while on the left it seems to lie much more caudally. DUBOIS emphasized that this sulcus in all anthropoids lies before the lambda suture, while it lies behind it, in men. In recent man this sulcus is more frequently expressed on the left (ELL. SMITH).

The same holds good for the lunate sulcus in Neanderthalmen, where according to BOULE and ANTHONY [5]) it is visible behind the lambda suture in the left hemisphere of the La Chapelle cast. ANTHONY [6]) indicates it in a similar position in the *La Quina* cast. I found it more clearly and in a similar position on the left hemisphere of the Düsseldorf cast, where even the posterior calcarine and part of the superior occipital fissure may be indicated.

ELL. SMITH [7]) mentions seeing this fissure on both sides in the Rhodesia cast, just in front of the lambda suture, but I consider the symmetrical

1) TURNER. Report of the Challenger. Zoology, Vol. **10**, part. 1 crania, London 1887, quoted from BURKITT and HUNTER. Description of a Neanderthaloid australian skull etc. Journal of Anatomy and Physiol. Vol. **57**, 1922.

2) DUCKWORTH. Studies in Anthropology, Cambridge University Press, 1909,

3) MC. GREGOR, Recent studies on the skull and brain of Pithecanthropus. Nat. History, Vol. **25**, p. 555, 1925.

4) This refers to FICK's Outan brain mentioned by ZIEHEN in Bardelebens Handbuch der Anatomie p. 365, but HAGEDOORN found a maximum skull capacity in one of BOLK's Gorillas of 655 ccm. See Anat. Anz. Bnd. **60**, 1925—26, p. 417.

5) BOULE et ANTHONY. l'Encéphale de l'homme fossile de la Chapelle aux Saints. l'Anthropologie, Vol. **22**, 1911. See also Journ. of Anat. and Phys, Vol. **51**, 1917.

6) ANTHONY. l'Encéphale de l'homme fossile de La Quina. Bulletins et mémoires de la Société d'Anthropologie de Paris, Mars, 1913 (fig. 10, p. 159).

7) ELL. SMITH. Rhodesian man and associated remains. Brit. Museum of Nat. Hist. publ. 1928.

C. U. ARIËNS KAPPERS: THE FISSURES ON THE FRONTAL LOBES OF PITHECANTHROPUS ERECTUS DUBOIS COMPARED WITH THOSE OF NEANDERTHAL MEN, HOMO RECENS AND CHIMPANZEE.

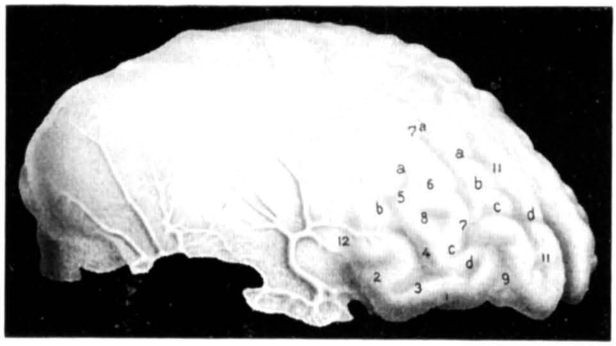

Fig. 1
right hemisphere.

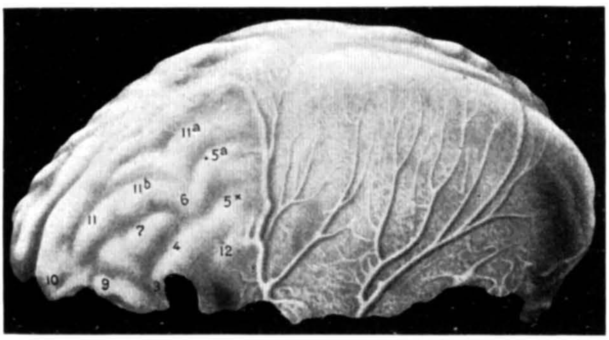

Fig. 2
left hemisphere.

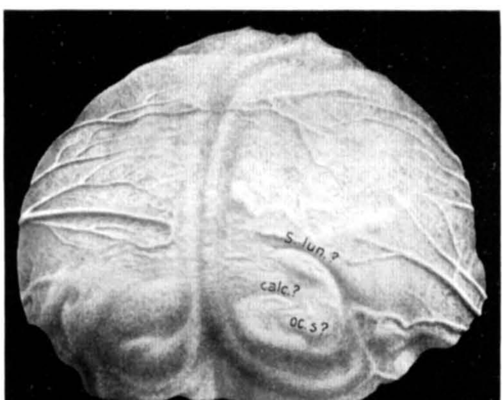

Fig. 3
occipital lobes

Vlassopoulos' drawings of the endo-cranial cast of Pithecanthropus erectus Dubois. In fig. 2 behind and under 9 (which refers to the sulcus in front of it) a vestige of fiss. 1 is seen.

indentation on these places as a result of a thickening of the posterior border of the parietal bone, which I also encountered in different recent skulls.

Concerning the *central sulcus* in Pithecanthropus and Neanderthal men I have to limit myself to suppositions concerning its ventral part. Perhaps a shallow groove behind *5b* on the left and behind 5* on the right side of the Trinil cast, just in front of the anterior branch of the arteria meningea media, represents this part. If this is true — of which I am not sure — the central end of the Rolandic fissure would closely approach the *s. subcentralis anterior,* and thus show a higher condition of development than in anthropoid apes, where its ventral end usually curves backward (fig. 5), although the limit of the sensory and motor area already in the Chimpanzee (BRODMANN [1]) takes a fronto-ventral course (an example of the retardation of sulci in adapting themselves to cytotectonic bordering lines [2]). For Neanderthal men ANTONY supposes the ventral end of this fissure also to lie near the anterior branch of the arteria meningea media (l.c. primo, p. 165 and l.c. secundo, p. 164; cf. also C? in my fig. 2 of La Quina r. and l.).

The length-width index of the endocranial cast of Pithecanthropus (81.2 according to my calculation) does not differ so much from that of Neanderthal men. According to ANTHONY's calculation this index in the Gibraltar cast is even 81.5 (according to mine 79.5). The latter found 78.3 and 78.6 for the Düsseldorf and La Chapelle casts, while I found the Düsseldorf cast to have even a little more (79.6).

From this it appears that also in the length width index of its cast (81.2) Pithecanthropus comes very near Neanderthal men, nearer than to the Chimpanzee (84.5) [3].

In a following paper I shall compare the endocranial casts of various Neanderthal men, and publish the drawings of these casts, made by the scientific artist Mr. CHR. VLASSOPOULOS, to whom I am also indebted for the excellent plate joining this paper.

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1) BRODMANN. Neue Ergebnisse über die vergleichende histologische Lokalisation der Groszhirnrinde mit besonderer Berücksichtigung des Stirnhirns. Verh. An. Ges. 1912.

2) For other examples of this retardation of sulci, see KAPPERS. Cerebral localization and the significance of sulci. Report of the XVII[th] international Congress of medicine, London, 1913.

3) For brain indices see "The influence of cephalization coefficient and body size on the on the form of the forebrain in mammals. Proceed. of the Kon. Akad. v. Wetensch., Amsterdam, Vol. **31**, 1927.